Analysis of ATC Systems Interference on Galileo Aeronautical Receivers

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Objectives

- This work started on September ’04, performed from AMS, University of Florence and ENAV, aims to evaluate the performances degradation of an Aeronautical Galileo receiver, due to interferences from the main operating Civil ATC systems
  - Primary Radars (L-band and S-band Radar)
  - Secondary Radars (Monopulse and Mode-S Radar)
  - DME, VOR, ILS
- We evaluated also the effects of the Galileo receiver mitigation techniques using the CNIT Galileo Simulator
- A theoretical approach has been also performed which confirmed that the DME systems could seriously affect the Galileo receiver performances without the activation of an appropriate mitigation technique

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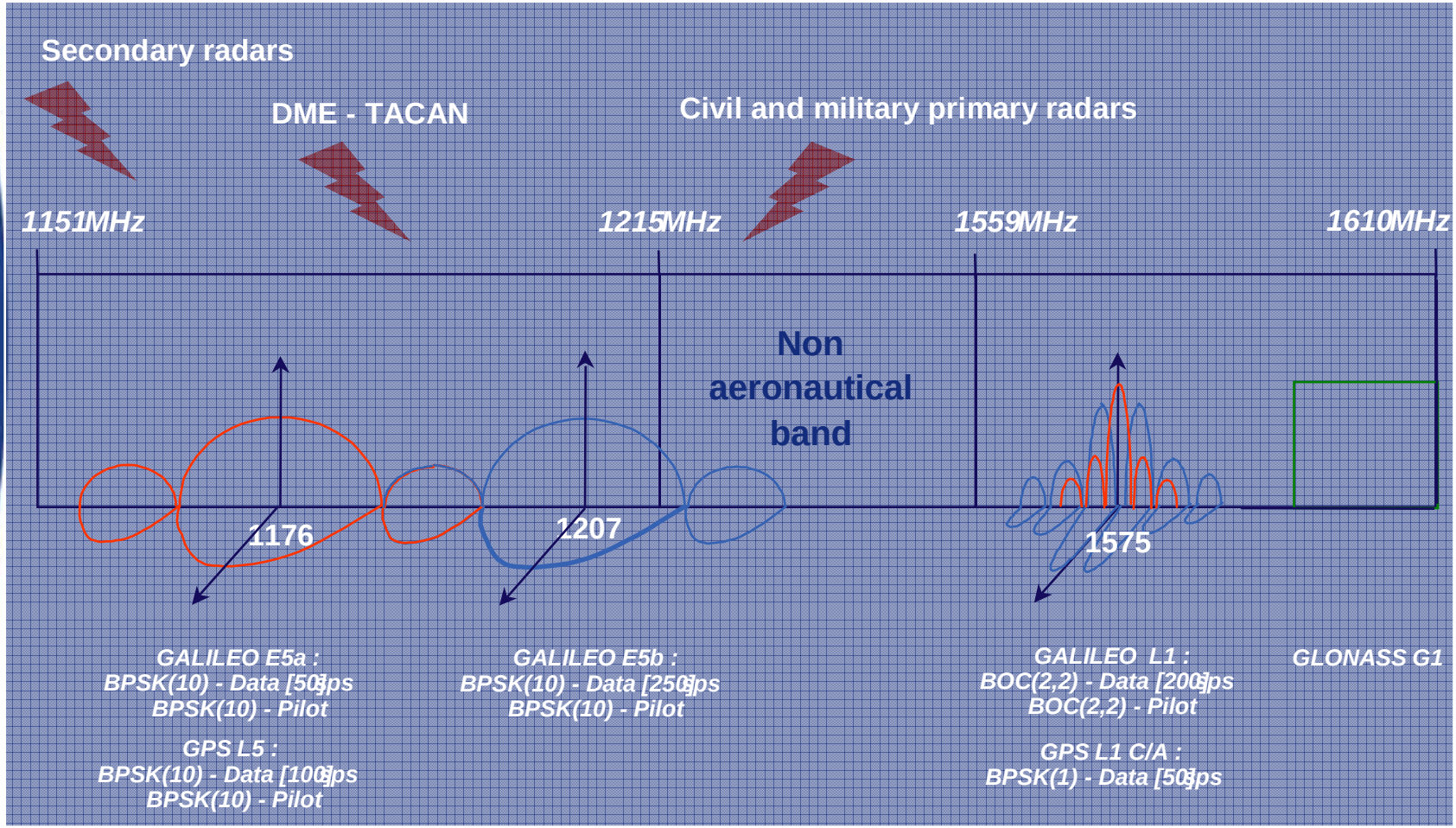
GNSS and ATC Equipment Frequency Bands



ATC Equipment not interfering with E5

- **S-band Radar**
  - 2700 – 2900 MHz
- **VOR (VHF Omnidirectional Radiobeacon)**
  - 108 – 117.975 MHz band
  - low power levels (50-100 W)
  - continuously radiated signal
- **ILS (Instrument Landing system)**
  - 108 – 117.975 MHz, and 328.6 – 335.4 MHz
  - low power levels (max 20 W)

Caused by their spectral separation from E5/L5 band, the interference is negligible

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Theoretical Approach (1/3)

$$EIRP = (P_{\text{int},tx})_{dBW} + L_{add} + G_e$$

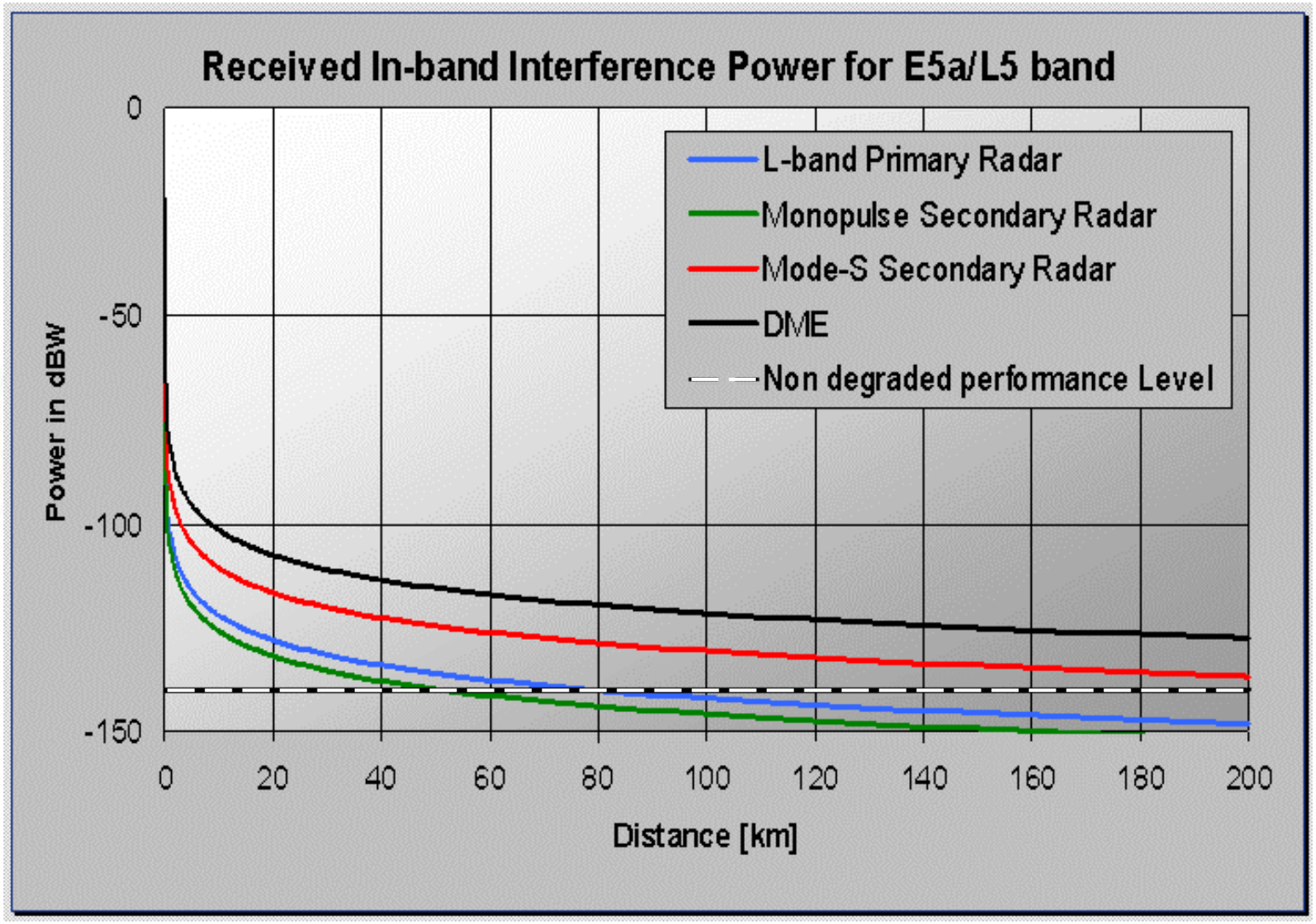
$$(P_{received})_{dB} = EIRP - L_{transmission} + G_r$$

$$L_{transmission} = L_{free\ space\ losses} + L_{diffraction}$$

$$L_{free\ space\ losses} = 20\log_{10}\left(\frac{4\pi d}{\lambda}\right)$$

Interference mean EIRP (in dBW)	In-band mean EIRP		Out-of-band mean EIRP
	E5a/L5	E5b	
L-band PSR	-8.2	1.8	65.1
Monopulse SSR	-12	-22	33
Mode-S SSR	3.2	-6.8	48.2
DME	12.3	12.3	12.3

Theoretical Analysis Results (2/3)



Results

- The results of the Theoretical approach show that in absence of any mitigation, the GNSS Aeronautical receiver performances may be seriously degraded by in-band and out-of-band interferences
- The major effect is produced from the DME systems
- Applying the blanking technique to mitigate the interferences, the effects could be substantially reduced

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Simulation

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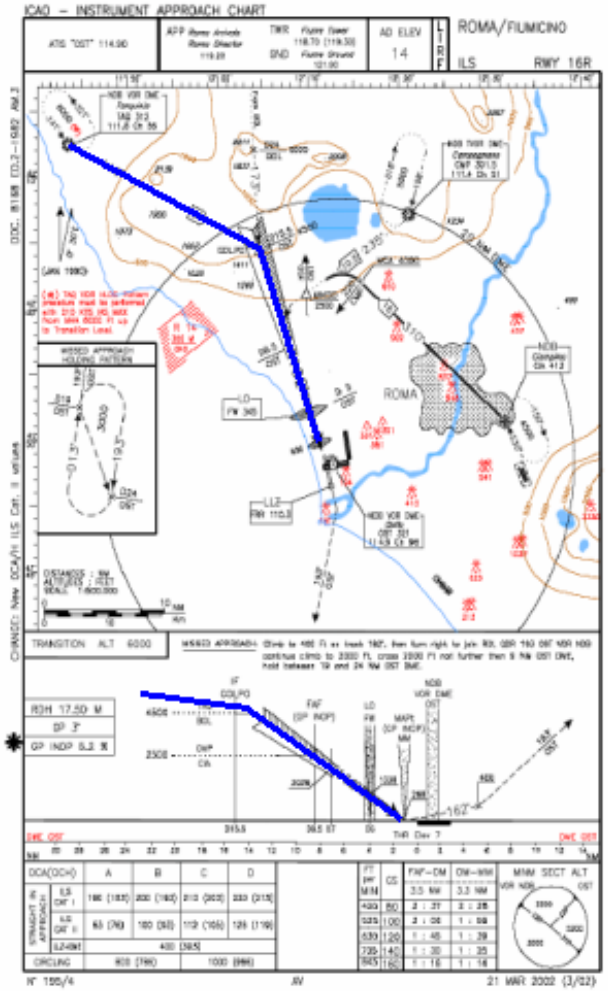
Simulator Scenario

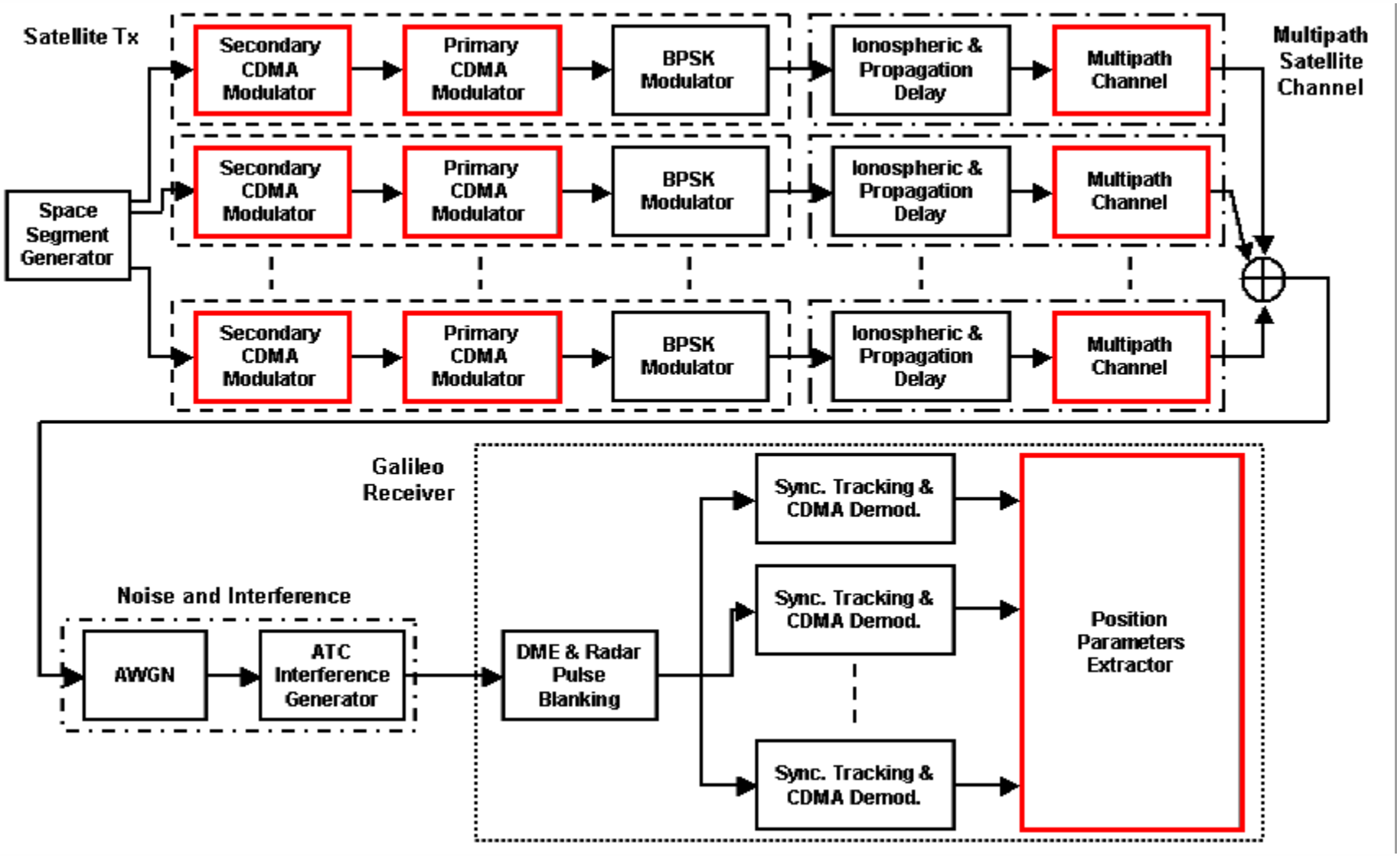


Real case Study: aircraft approaching Roma-Fiumicino Airport

Main ATC Interference Sources

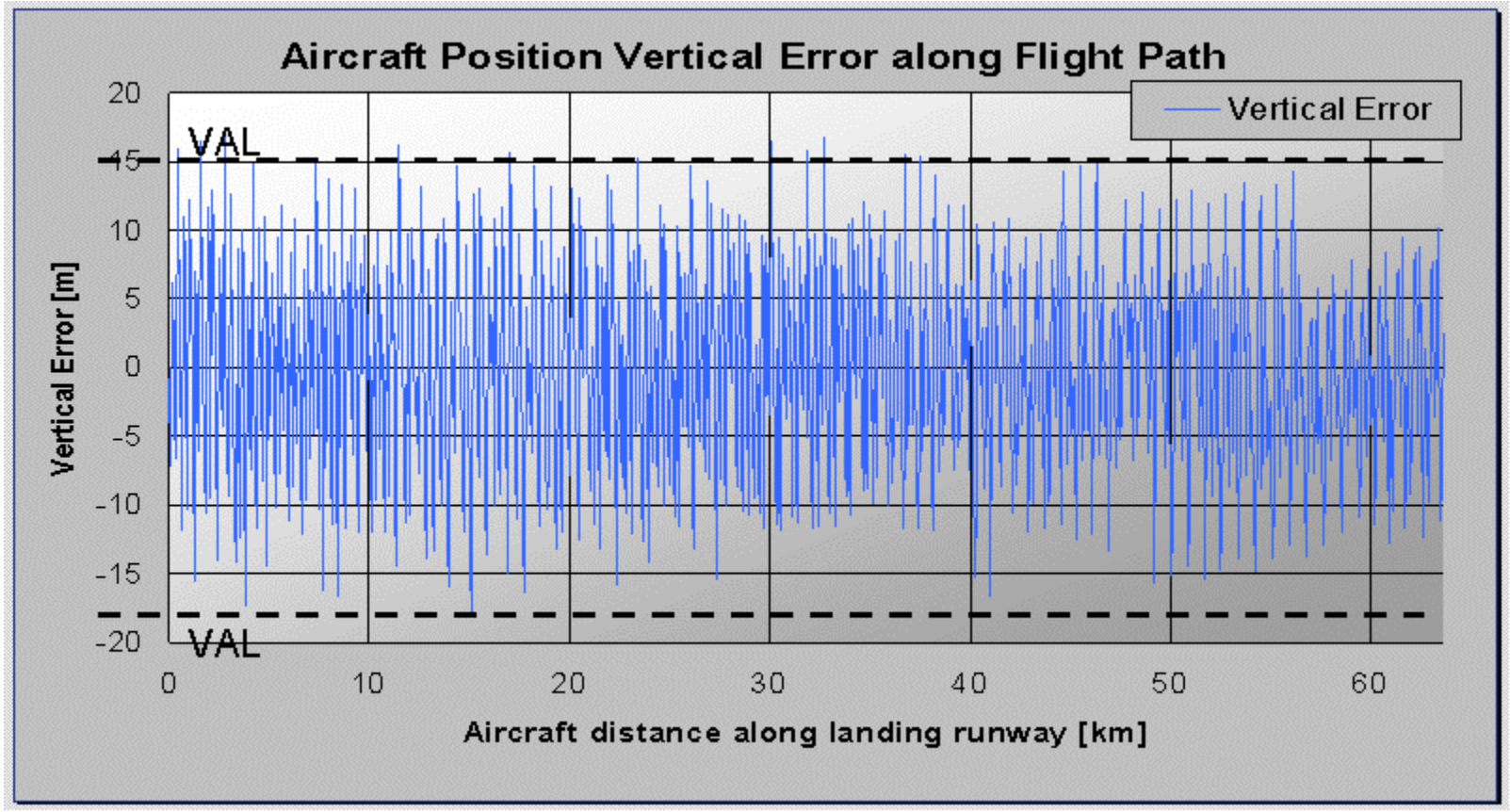
- L-band Primary Radar ATCR44-S
- S-band Primary Radar ATCR33-S
- Monopulse SIR-M Secondary Radar
- Mode-S SIR-S Secondary Radar
- 5 DME – Distance Measuring Equipment
- 4 ILS (1 for each landing runway)
- 4 VOR

CNIT Galileo Simulator



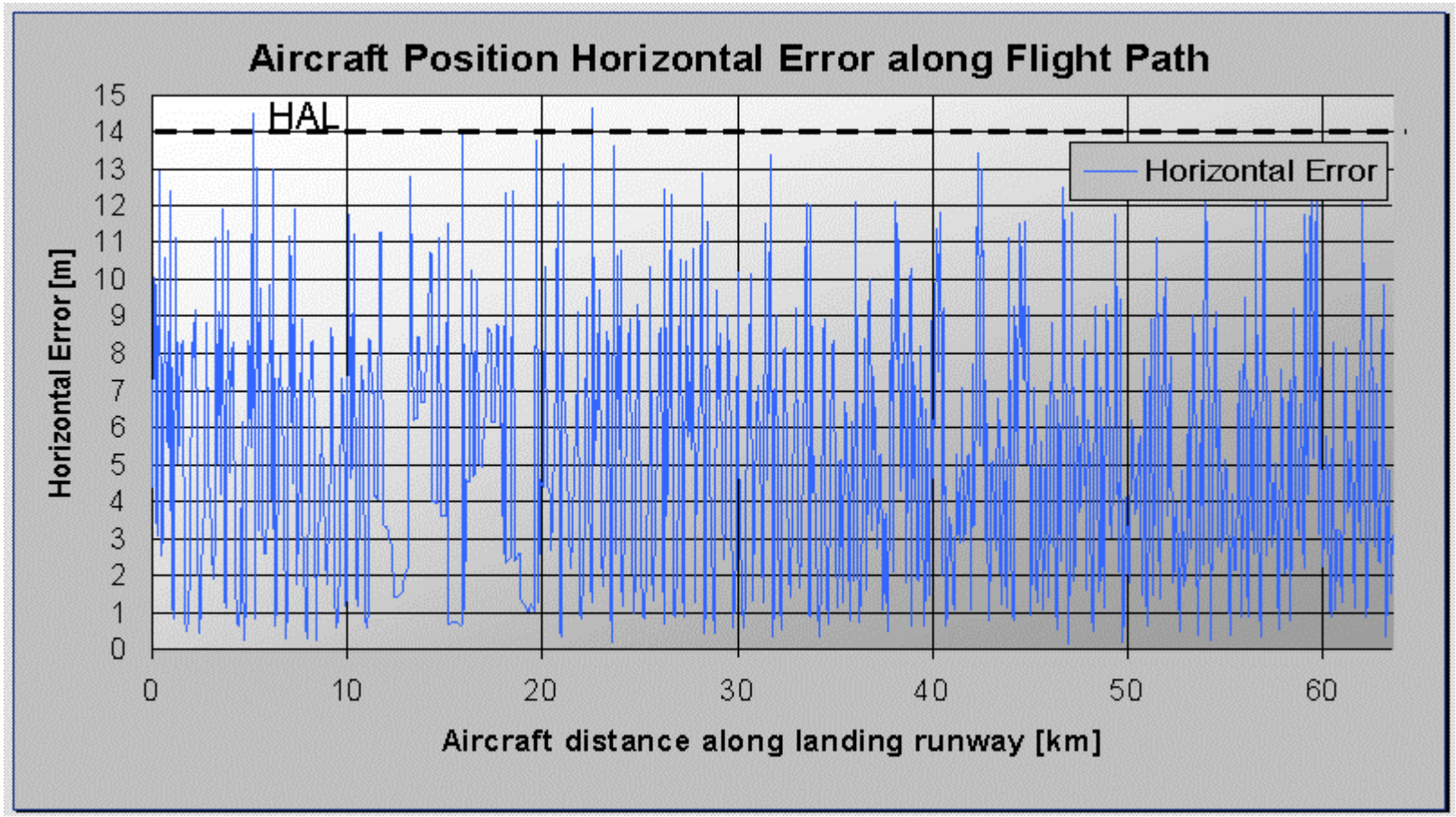
Main Results

Vertical Error - In-band Interference @ E5A, L-band Primary Radar



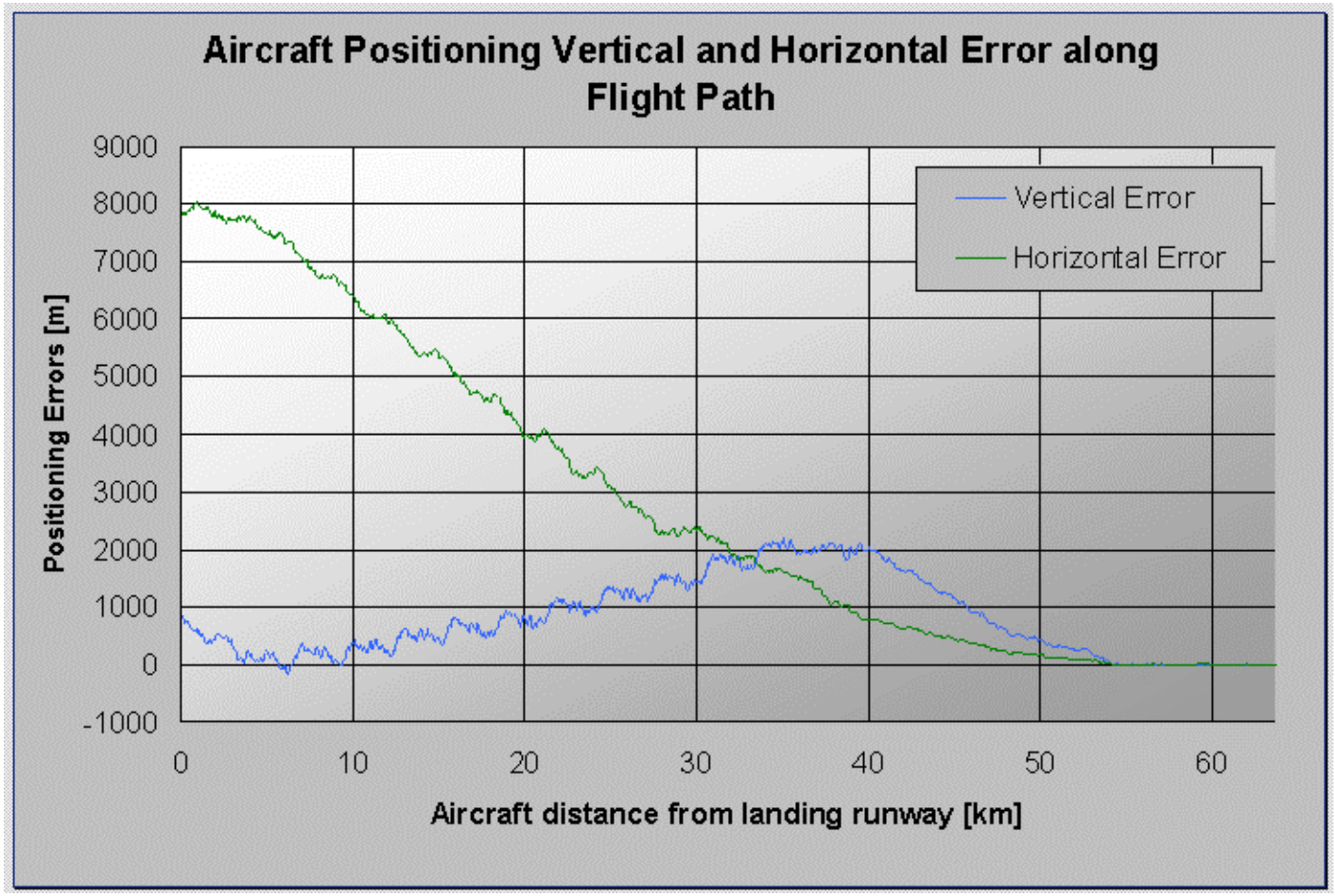
Vertical Service Availability: 96.5% - NO MITIGATION TECHNIQUES

Horizontal Error - In-band Interference @ E5A, L-band Primary Radar



Horizontal Service Availability: 99.4% - NO MITIGATION TECHNIQUES

Horizontal and Vertical Error for In-band Interference, E5A, DME

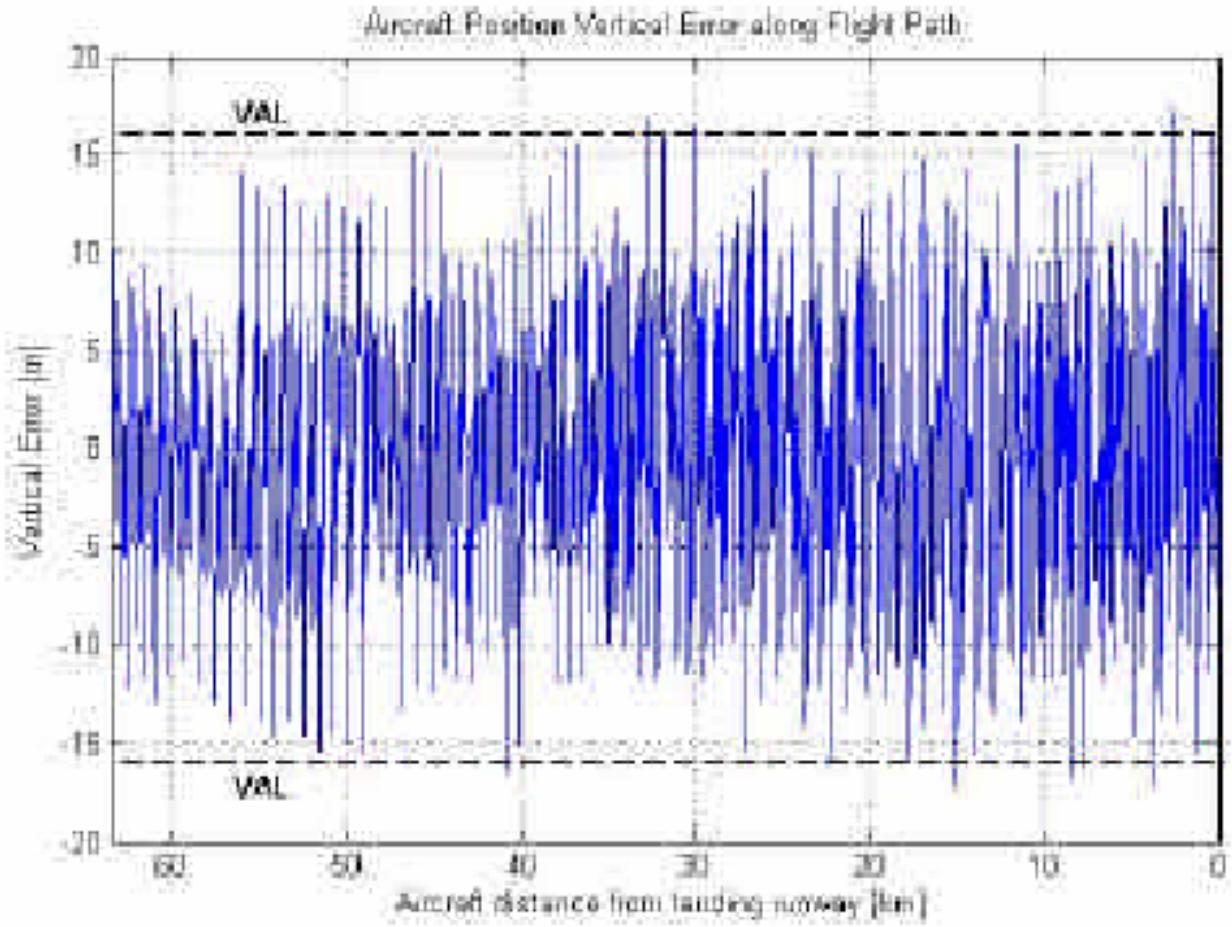


Service Availability: 11.5%

Behavior of the GNSS receiver in presence of ATC sources (No Pulse Blanking)

Receiver Behavior	In-band Interference		Out-band Interf.
	E5a/L5	E5b	
L-band PSR	Good	Good	Good
Monopulse SSR	Good	Good	Good
Mode-S SSR	Good	Good	Good
DME	Bad	Bad	Good
All Sources	Bad	Bad	Good

Vertical Error for In-band interference, E5a band, DME with Pulse Blanking



Conclusions

- L-band and S-band PSR, SSR, VOR, ILS interferences are not significative on accuracy and Service Availability
- DMEs have a heavy effect on accuracy and Service Availability (e.g. loss of Galileo SIS code tracking), but a simple mitigation technique is able to strongly reduce the impacts in the most cases
- The analysis of the results are still underway

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Thank you for the attention !

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